Renewable and Sustainable Energy Reviews 26 (2013) 822–836

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A review of biofuel policies in the major biofuel producing countries of ASEAN: Production, targets, policy drivers and impacts

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ARTICLE INFO

Article history:
Received 11 September 2012
Received in revised form
4 June 2013
Accepted 16 June 2013
Available online 17 July 2013

Key words:
ASEAN
Biofuel
Policies
Drivers
Impacts
Second generation

ABSTRACT

Since the turn of this century, development of biofuels have progressed rapidly in Indonesia, Malaysia, Philippines and Thailand—the major biofuels producing countries in the ASEAN (Association of South East Asian Nations). The article analyses the biofuel polices, underlying drivers, and way forward for sustained biofuel development in these countries. Favorable regulatory and economic mechanisms have played an important role in the production, utilization and market penetration of biofuels in these countries. A large variety of biofuel support policies are in place ranging from policy targets, blending mandates, tax incentives and other financial schemes to stimulate the development and adoption of biofuels. Indonesia is leading the region in biodiesel production and Thailand is leading in ethanol production. Though each of these countries have had occasional setbacks in their production, in totality, there has been positive growth in biofuel production and an upward trend in future is likely with increased demand, consumption, enforcement of mandates and realization of policy targets. The biofuel development of these countries is motivated by several factors, mainly their concerns for energy security (e.g. to reduce the dependence of oil imports) and socio-economic development (e.g. to increase income generating opportunities). Climate change is not the primary motive of these countries to pursue biofuel development. However, sustainable production of biofuels and reliance on second generation biofuels can provide opportunities for these countries to translate their growth potential into economic revenues under carbon finance and thus address greenhouse gas emissions and climate change concerns.

Contents

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1364-0321/$ - see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.rser.2013.06.007

1. Introduction

Biofuels are receiving increasing global attention as an alternate energy resource as they address energy security, climate change and poverty reduction [1–5]. This can be seen from the increase of biofuel production (and consumption) around the world. From the turn of this century, till 2011, world ethanol production increased from 17 to 86.1 billion l, while that of biodiesel grew from 0.8 to 21.4 billion l [6]. Global biofuel production had annual increase of almost 13% in 2010 [7] (see Fig. 1).

Globally, Brazil and United States lead in biofuel production, and several Asian countries are also actively promoting biofuel development. Particularly in the ASEAN (Association of Southeast Asian Nations), Indonesia, Malaysia, Philippines, and Thailand have accelerated their attempts to develop the biofuel industry. For example, Indonesia and Malaysia, the two largest producers of palm oil in the world, together account for 85% of world's palm oil [4]. In order to promote the development of biofuels and its penetration in the market, these ASEAN countries have put forward policies, plans, blending mandates, incentives, etc. The rapid expansion of biofuel production witnessed over the last few years in these countries has been largely policy driven [1,8,9] (in the pursuit of energy security or lowering greenhouse gas emission or improving rural development [1,3,5,10]).

To understand how biofuel policies have promoted the growth and development in these ASEAN countries, an assessment of biofuel policies is the subject of this article. Biofuel policies for this study refer to policies, plans, programs that have been introduced to promote and regulate the production and consumption of biofuels—both biodiesel and ethanol. ASEAN is a geo-political organization of ten member countries. Indonesia, Malaysia, Philippines, Singapore, and Thailand are the founding members, and Brunei Darussalam, Vietnam, Lao PDR, Myanmar and Cambodia are the other members. For the purpose of this study, the ASEAN region denotes the major biofuel producing nations in this region, namely Indonesia, Malaysia, Philippines, and Thailand. The paper investigates the biofuel development in these countries, influence of the policies and plans to this sectoral development, including the underlining drivers promoting biofuel development, adoption and utilization in the region.

The research is based on review of literature, information and analysis of secondary data obtained from various sources, published databases, official reports and statistics. The first part of the paper reviews the biofuel policies of the selected ASEAN countries to understand in what way the policies have fostered the production and utilization of the biofuels. The second part of the paper explores the underlying drivers for biofuel development in these countries and the third part discusses the commonalities and differences. The paper concludes with a discussion on the implication of the biofuel development in these countries.

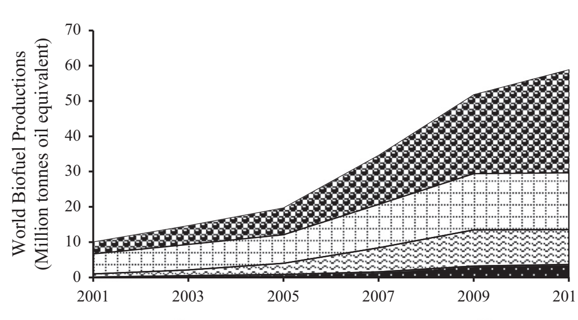

Fig. 1. World Biofuels production in million tones oil equivalent (Data obtained from BP Statistical Review [7]).

2. Biofuel policies

This section reviews the biofuel policies in the selected ASEAN countries and discusses the influence of their policies in the production and utilization of biofuels .

2.1. Malaysia

2.1.1. Policies

Malaysia launched the Four-Fuel Diversification Policy in 1981, focusing on four main sources of fuel, namely oil, hydro, gas and coal. The policy was aimed at reducing dependency on oil in energy consumption particularly in the power sector. In 2005, this policy was expanded to include renewable energy (RE) as the fifth fuel to supplement energy supply from conventional energy resources [11]. Recognizing its potential for the biofuel market, the Malaysian government in 2006, adopted the National Biofuel Policy, in line with nation's Five-Fuel Diversification Policy, to promote the production and consumption of biodiesels underpinned by five strategic thrusts (i.e. Biofuel for Transport, Industry, Technologies, Export and Cleaner Environment) and launched B5 i.e. blended diesel with 5% palm oil.

The Malaysia's policy on biofuel was formulated with an expectation to bring the following benefits (The National Biofuel Policy, 2006 [12]): mitigating effect of petroleum price escalation, savings in foreign exchange, environment friendly source of energy, new demand for palm oil, mutually beneficial effects on

petroleum and palm oil sectors, achieving socio-economic safety nets, efficient utilization of raw materials.

The development of Malaysian biofuel policy is primarily aimed at reducing the country's dependence on depleting fossil fuels, promoting the demand for palm oil as well as stabilizing its prices at remunerative level. For example, the policy envisaged that blending 5% of palm oil with all diesels in the country would create demand for 500,000 t of palm oil equivalent to replacing 40–50% of the national stock of palm oil. Being one of the largest producers and exporter of palm oil, the policy expects the creation of new markets to use palm oil as a diesel substitute, locally and overseas. The policy also addresses environmental concerns as it envisaged that the use of palm oil as biofuel would indirectly reduce the emissions of greenhouse gases.

The Ninth Malaysian Plan (2006–2010) further emphasized the increased use of biofuel as a renewable energy source [4]. Following the development of National Biofuel Policy, the Malaysian Biofuel Act 2007 (enforced in November 2008) regulated the mandatory use of biofuel and licensing of activities related to its production, storage and trade.

2.1.2. Government incentives

In support of the biodiesel industry, the Malaysian government introduced several incentives, taxes and levies. As tax incentives to biodiesel manufacturers, biodiesel projects are eligible for Pioneer Status of Investment Tax Allowance (ITA) under the Promotion of Investments Act of 1986 [13]. A company with Pioneer Status is granted tax exemption on at least 70% of the income derived from the biodiesel production for 5 years with more revenue eligible under certain provisions. Under ITA, companies are granted an allowance of 60% for qualifying capital expenditure incurred within 5 years or up to 70% exemption of the statutory income derived from biodiesel in the assessment year [13]. Between 2004 and 2006, the government also allocated US $26.8 million in the form of low-interest loans and federal grants for research, development and demonstration projects [14].

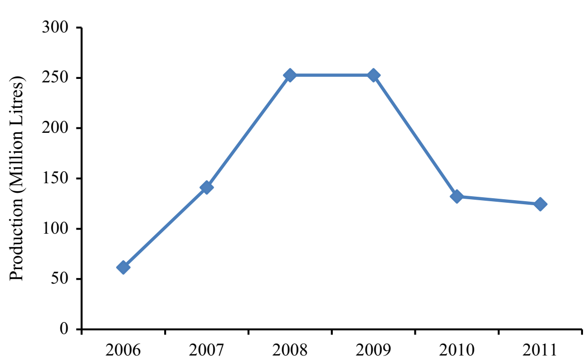

Fig. 2. Biodiesel production in Malaysia (Data obtained from BP Statistical Review [7].).

2.1.3. Production and utilization

Ethanol production has been commercially insignificant in Malaysia and although opportunity for ethanol production from oil palm biomass exists, the technology has not been fully commercialized [15]. With the increase in palm oil production and after the promulgation of biofuel polices in 2006, there was significant growth of biodiesel production in Malaysia during 2007 and 2008 (see Fig. 2). The government also pledged 6 million t of Crude Palm Oil (CPO) for biodiesel production and Malaysia's first commercial-scale biodiesel plant began operations in Pasir Gudang, Johor [14]. By August–December 2006, 55,000 t of biodiesel was produced which increased to 130,000 t in 2007, and by the end of September 2007, the government had approved 92 licenses for individual biodiesel projects with a combined production capacity of 10.2 million t [14]. However, many of these proposed were delayed or canceled due to the dwindling viability of biodiesel, resulting from increasing palm oil prices [14].

The production level of biodiesel decreased after 2009 mainly due to increased feedstock prices of CPO. Furthermore, 2009 witnessed a series of debates in Europe, the largest importer of biodiesel, about the compliance of palm oil based biodiesels with sustainability criteria i.e. minimum reduction in greenhouse gas emissions compared with diesel produced from fossil fuels [15]. The palm based industries in Malaysia (and Indonesia) suffered due to non-compliance with EU standards. During the first half of 2011, biodiesel production was at standstill in Malaysia as the companies were unable to maintain operations due to high cost of feedstock and only few plants were operating sporadically [16]. Decline in production in 2011 was evident as the EU's Renewable Energy Directive (RED) requirements came into full force at the end of 2010 [17]. Increase in the production in the coming years will be possible once the certification systems pursued by the palm oil companies in Malaysia meet the sustainability and environmental requirements under EU-RED. The Malaysian government had originally set 1 January 2010 as the deadline to sell B5 biodiesel at all petrol stations nationwide, but due to high palm oil prices and the large government subsidy needed, the implementation of B5 mandate was delayed to June 2011, and limited to the central region of Malaysia [14]. It appears that the production will not increase any time soon as most biodiesel plants remain idle [18].

Since the Malaysian Biofuel Industry Act came into force, a number of biodiesel companies were registered. The government had approved more than 50 license for biodiesel production, most of which were either delayed or canceled [14]. Only few biodiesel plants were operational and many of them are operating below their installed capacities [14]. The recent setback on the production and export on biodiesel has been mainly due to increased palm oil prices. Table 1 presents the biodiesel plants approved/registered after the enactment of biofuel policy in 2006.

Table 1
Number of biodiesel plant approved/registered in Malaysia (2006–2011).

Year	No. of approved/registered biodiesel plants	Combined production capacity	References
2006	1 (First commercial scale biodiesel plant in operation)	55,000 t	[14]
2007	6 (operational)	~272,000 t	[13]
2008	12 (not all were operational)	~2 million t	[19]
2009	12	~2.2 million t	[20]
2010	20 (not all were operational)	~1.8 million t	[16]
2011	28 (most were idle)	~2.3 million t	[18]

2.2. Indonesia

2.2.1. Policies

The energy policy of Indonesia has the following underlying objectives [21]: (1) energy diversification by expanding the use of coal, gas and renewable energy resource to reduce dependence on oil; (2) rational energy pricing by eliminating unwanted subsidies; (3) energy sector reform to attract greater involvement and capital investment in energy sector; and (4) rural electrification.

The National Energy Policy (Regulation no. 5/2006) was formulated with a goal to create sufficient domestic energy supply which sets energy diversification targets that include 5% biofuel in the country's total energy mix in 2025. The plan following the policy (known as Losari concept which intended to replace 10% of transport fuel in 2010 by biofuels) was formulated mainly to improve energy security, economic growth, create employment and reduce poverty in rural areas [22]. Similarly, the President Instruction no. 1 on Supply and Use of Biofuel was formulated to accelerate biofuel utilization as an alternative to fossil fuel. The government had announced a New Deal Program as part of Biofuel Program with targets for 2006–2010 as [23]: additional job creation for 3.6 million people, poverty level reduction by 16%, subsidized value for palm oil mill cut by Indonesian Rupiah 9 trillion (around US$ 0.9 billion), value of imported oil decreased as much as US$ 4.96 billion, and millions hectares of non-productive land utilized.

The Indonesian government has developed several strategic points targeted for 2015 and 2025. The Indonesian roadmap for biofuel development targets biofuel mix of 2%, 3% and 5% in the country's total energy mix in 2010, 2015 and 2025, respectively [3]. Individually, the biodiesel share in the transportation sector would amount to 20% by 2025 and the ethanol component of the gasoline would increase to 15% in 2025 [24].

2.2.2. Government incentives

After the formulation of National Biofuel Policy, initially, the state owned oil company Pertamina was forced to sell 5% biofuel blends (palm oil derived biodiesel) to the local market at the same price as subsidized fossil fuel, and thus the Indonesian government indirectly subsidized biofuel sales [9,25]. There exists regulation (Government Regulation no. 1/2007, adopted in January 2007) to provide income tax reductions on investments in specific regions or industries, including bioenergy, but the implementation impacts of the regulation is not available [22]. There are also measures to encourage the development of new biofuel feedstock plantation, and the renewal of existing plantations to improve seedling quality and encourage value-added production [22]. More recently, the Ministry of Energy and Mineral Resources' Directorate General of New and Renewable Energy and Energy Conservation (EBTKE) and the state-owned oil company Pertamina have enforced some mandatory requirements of domestic biodiesel consumption. For example, as of July 2012, Indonesian coal and mineral mining companies are required to consume 2% biofuels in their total fuel consumption [26]. Overall, though there is no clear tax incentives for biofuel manufacturers in Indonesia, measures such as fuel subsidies and blending mandates have played an important role in the production of biofuel.

2.2.3. Production and utilization

Prior to 2006, the production of ethanol in Indonesia was for industrial purposes, for cosmetics, paint, and pharmaceuticals, and only after the enactment of Presidential Regulation no. 5/2006, mandating the use biofuels at 5% of domestic energy needs by 2025, the country began producing ethanol at 0.3 million l in 2006 which increased to 1.7 million l in 2009 [27]. However, fuel ethanol production terminated since 2010 (Fig. 3) due to disagreement in market price index formulation between Ministry of Energy and Mineral Resources and fuel ethanol producers [28]. The feedstock used for ethanol production in Indonesia was molasses sourced from domestic sugar refining.

In contrast to ethanol, the biodiesel production in Indonesia has increased considerably (Fig. 4) over the years i.e. from 65 million l in 2006 to 1520 million l in 2011 [26] with few setbacks in production during 2008–2009. Initially in 2006, when the prices of agricultural commodity was low and export prospect was lucrative, biofuel development was an attractive option and combined with government's biofuel infrastructure subsidies, production of biofuel increased [23]. However, the soaring price of CPO during 2008 made biofuel production unprofitable and with limited government assistance, many refineries suspended their operation, which decreased the production drastically in 2009. When the prices of both petroleum and biofuels began to ease, the producers increased production level and several new plants 2010 onwards came into operation [23].

Since the Indonesian biofuel policy was developed, a number of biofuel companies were registered (see Table 2). However, many of them are still operating below their installed capacity mainly because of increased palm oil prices.

2.3. Thailand

2.3.1. Policies

Thailand produces both ethanol and biodiesel due to its resources of cassava, sugarcane, and palm oil. It is one of the leading ASEAN countries to establish policies to promote biofuel production to reduce its dependency on oil imports and to capitalize on its supplies of feedstock from its agricultural production [29]. The Thai government built and modified several plans and policies to increase the production and consumption of

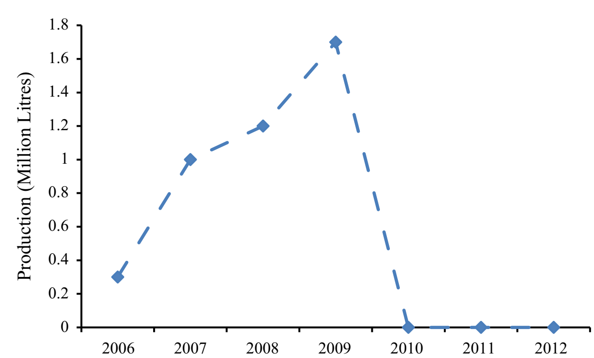

Fig. 3. Ethanol production in Indonesia (Data obtained from Slette and Wiyono [26]. The values for 2012 are post estimates.).

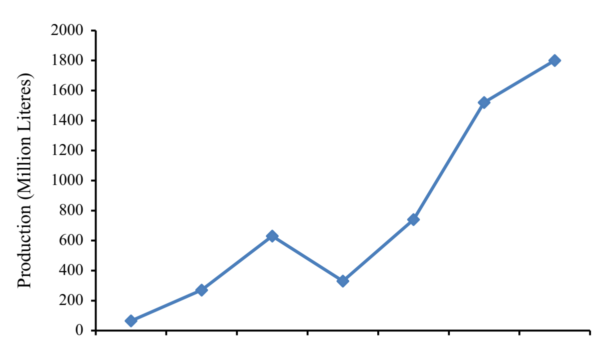

Fig. 4. Biodiesel production in Indonesia (Data obtained from Slette and Wiyono [26]. The values for 2012 are post estimates.).

Table 2
Number of biofuel plants approved/registered in Indonesia (2006–2011) [26].

Year	No. of approved/registered fuel ethanol plants			No. of approved/registered biodiesel plants		
	No. of ethanol plants	Combined production capacity (million l)	Capacity in use (%)	No. of biodiesel plants	Combined production capacity (million l)	Capacity in use (%)
2006	1	10	3	2	215	30
2007	1	13	8	7	1709	16
2008	4	243	0	14	3138	20
2009	5	273	1	20	3528	9
2010	5	273	0	22	3936	19
2011	5	273	0	22	3936	39

biofuels. The underlying guiding principles of Thailand's national energy policy are to [30]: establish sustainable energy security; expedite and promote alternative energy; monitor energy prices and ensure appropriate levels, in line with wide and investment situation; effectively save energy and promote energy efficiency; and support energy development while simultaneously protecting the environment.

The policies and programs to promote biofuels were built on the first national Alternative Energy Development Plan (AEDP) 2004–2011 and the second Alternative Energy Development Plan 2008–2022 [29] to increase the share of renewable energy mix to be 20% of the country's total energy demand by 2022. The 15 years AEDP (2008–2022) set ambitious production targets for both ethanol and biodiesel in short term (by 2011), medium term (2016), and long term (by 2022). The government further revised its AEDP plan with a target of using renewable energy at 25% of total energy consumption by 2021 [31].

The AEDP (2012–2021) envisages achieving the following objectives [31]: develop renewable energy as a major energy supply of the country for replacing fossil fuel and oil import; strengthen the energy security of the country; promote an integrated green energy utilization in communities; support development of domestic renewable energy technology and industry; and research, develop and promote domestic renewable energy technology in international market.

Based on AEDP plan, subsequent plans for ethanol and biodiesel development for short, medium and long term have been formulated. The ethanol plan set production targets of ethanol at 3.0, 6.2 and 9.0 million l/day for short term (by 2011), medium term (by 2016) and long term (by 2021), respectively [31,32]. Similarly, the biodiesel plan set production targets of biodiesel at 3.0, 3.6 and 5.97 million l/day for short term (by 2011), medium term (by 2016) and long term (by 2022), respectively [31,32].

2.3.2. Government incentives

To operationalize the ethanol development as per AEDP (2012–2021) target, the government set measures, among others, as follows [31]:

- Set targets in increasing the national average production of cassava and sugarcane and promote commercial production of alternate feedstock like sweet sorghum.
- Terminate using 91 benzene by October 2012.
- Subsidize E20 gasohol[1] at 3 bhat/l (about 10 US cents/l) cheaper than Octane 95 gasohol and extend E20 service stations.
- Support the manufacturing of Eco-Car and E85 car in general, by reducing excise tax to car makers for 50,000 baht (about 1600 US dollars) per each E85 Car and 30,000 (about 1000 US dollars) baht for each of Eco-Car.
- Amend laws and regulations to support ethanol free trade and amend excise tax to support ethanol export.

Similarly, for biodiesel development, the measures set by the government, among others, are as follows [31]:

- Palm plantation to be done in appropriate areas not competing with food crops, together with improvement in the production capacity and yield.
- Set compulsory biodiesel blending requirement (B5 currently) and manage the proportion of blending relevant to domestic palm oil production.
- Conduct pilot fueling of B10 or B20 and prepare the blending share to be upto 7% in diesel oil.

2.3.3. Production and utilization

Among the developing countries in Asia, Thailand has the highest fuel ethanol growth rates. Although Thailand had required either methyl tert-butyl ether (MTBE) or ethanol to be blended with premium gasoline (Research Octane Number 95) for over a decade, it was not until 2003 that oil companies began to market E10 gasoline [34]. The Government set the National Ethanol Program and Gasohol Strategic plan on December 6, 2003 with an ethanol production target of 1.0 million l/day by the end of 2006 and 3.0 million l/day by the end of 2011. The provision of excise tax incentive made E10 1.50 baht/l (5–6%) cheaper than premium gasoline in 2005. Also the launch of E20 gasohol in 2008 at a price 6 baht/l lower than pure gasoline and 2 baht/l lower than E10 gasohol increased gasohol production, with similar increase in 2009 [34,35]. Unlike biodiesel, the government did not regulate compulsory use or sale of gasohol to substitute for regular gasoline, but the gasohol prices remained 10–15% below regular gasoline prices due to excise tax, plus a price subsidy for E20 and E85 gasohol derived from the State Oil Fund [36]. Although the ethanol production fell short of achieving the production target of 3.0 million l/day in 2011, the production has been in upward trend and the growth is likely to continue with increase in number of E20 vehicles, E20 gasohol stations, tax incentives for Eco-Car manufacturers and phase of out of gasoline 91 from the market [31,32]. Fig. 5 shows the biofuel production including ethanol and biodiesel production in Thailand, as well as the targets until 2021.

Although ethanol and biodiesel had been promoted at the same time in Thailand, ethanol had successfully penetrated the market before biodiesel because of its feedstock supply readiness [37]. In 2005, Thailand began a campaign to promote biodiesel production and consumption but the initial production of biodiesel was insignificant until February 1, 2008, when the government adopted a policy requiring compulsory production of B2 biodiesel [38]. A number of biodiesel producing plants were added

[1] Ethanol blended with gasoline is marketed as 'gasohol' In Thailand i.e. E10, E20 and E85. E10, a 10% blend of bioethanol with 90% gasoline, was introduced in the market in 2004. E20, a 20% ethanol blend, was introduced in 2008 after E10 had penetrated the market. Moreover, E85 gasohol was also introduced in the local market in August 2008 [33].

subsequently and biodiesel production increased in 2009 and 2010 due to requirement of compulsory use of B100 for B2 production and increased B5 biodiesel demand [38]. However, factors such as under-targeting planting i.e. limited palm growing area due to competitive rubber plantations, lack of suitable land for palm plantation and unpredictable weather hindered the accomplishment of the biodiesel development goals in 2011. The government had to ease the compulsory biodiesel production policy back and forth (from B3 to B2 and again to B3) for certain period [29]. With growing biodiesel consumption and implementation of B5 mandate since 1 January, 2012, biodiesel production is likely to grow upward in coming years.

A number of biofuel producing companies have been started in Thailand after the government pursued rigorous policies for alternative energy development including biofuels. Table 3 shows the number of ethanol and biodiesel plants developed since 2006 in Thailand.

2.4. Philippines

2.4.1. Policies

The Philippines produces both ethanol and biodiesel due to its resources of sugarcane and coconut oil. Coco-methyl ester (CME) derived from coconut oil (CNO) is the major feedstock used for Philippine biodiesel production, the country being the largest CNO producer in the world [39]. Philippine is one of the first countries in Southeast Asia to establish a law on Biofuels and to set decisive mandates on the use of biofuels. In January 2007, President signed the Republic Act 9367 (RA 9367) or the Biofuels Act of 2006.

The Biofuels Act 2006 (RA 9367) was formulated mainly to [40]: develop and utilize renewable energy sources to reduce dependence on imported oil; mitigate toxic and greenhouse gas (GHG) emissions; increase rural employment and incomes; and ensure the availability of alternative and renewable clean energy without any detriment to the natural ecosystem, biodiversity and food reserves of the country.

The act [40] mandates that: within three months from the affectivity of the act, a minimum of 1% biodiesel by volume shall be blended into all diesel engine fuels sold in the country which increases to 2% blend 2 years later; within 2 years from the affectivity of the act, at least 5% ethanol shall comprise the annual total volume of gasoline fuel actually sold and distributed by each and every oil company in the country, subject to the requirement that all ethanol blended gasoline shall contain a minimum of 5% ethanol fuel by volume; and within 4 years from the affectivity of the act, a minimum of 10% blend of ethanol by volume is contained in all gasoline fuel distributed and sold by each and every oil company in the country.

The act established the biofuel program with objectives of achieving energy independence through reduced oil import, meeting environmental challenge through GHG mitigation, and increasing rural employment and income [41,42]. Although the Philippine energy plan had a target to reach energy self-sufficiency level of 60% by 2010 and beyond, the target maximum substitution by biofuels for transport fuel is only 2% and 10% for biodiesel and ethanol, respectively [39]. The Biofuels Act imposes mandatory requirements to blend biofuels with gasoline and diesel in the transport sector, thus supporting the development of alternatives to fossil fuels [43].

2.4.2. Government incentives

To encourage investments in the production, distribution and use of locally-produced biofuels for the above minimum mandated blends, the following incentives are provided under the act [40]. The specific tax on local or imported biofuels component, per liter of volume is zero. The sale of raw material used in the production of biofuels, such as coconut, jatropha, sugarcane, cassava, corn, and sweet sorghum is exempt from the value added tax. All water effluents are exempted from wastewater charges under the

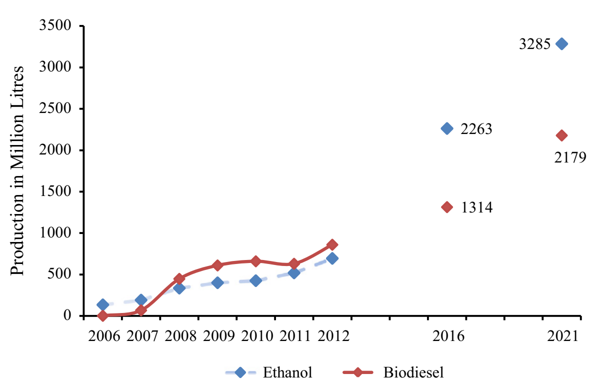

Fig. 5. Ethanol and Biodiesel production in Thailand and the production target (Data obtained from Preechajarn and Prasertsri [32]. Data for 2012 are post estimates and the data for 2016 and 2021 are based on the government's policy target for ethanol and biodiesel production.).

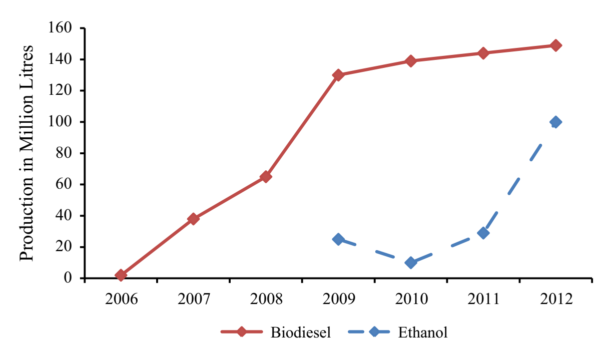

Fig. 6. Biofuel (ethanol and biodiesel) production in Philippines (Data obtained from Corpuz [45].The data for 2012 are post estimates.).

Table 3
Number of biofuel plants approved/registered in Thailand (2006–2011) [32].

Year	No. of approved/registered fuel ethanol plants			No. of approved/registered biodiesel plants		
	No. of ethanol plants	Combined production capacity (million l)	Capacity in use (%)	No. of biodiesel plants	Combined production capacity (million l)	Capacity in use (%)
2006	5	284.7	48	3	219	1
2007	7	350.4	54	5	475	14
2008	11	584	58	9	840	53
2009	11	620.5	65	14	1970	31
2010	19	1058.5	40	13	1970	34
2011	19	1058.5	50	13	1970	32

Philippine Clean Water Act. To encourage domestic production, the financial institutions, such as the development banks and other government institutions accord high priority to extend financing of at least 60% of the capital stock to Filipino citizens engaged in production, storage, handling, blending and transport of biofuel and biofuel feedstock.

2.4.3. Production and utilization

Domestic bio-fuels production was initially only limited to coco methyl ester (CME) or coco diesel and the production of bio-ethanol using sugarcane as feedstock, commenced only in 2008 [44]. The commercial production of bio-diesel started in 2004 in response to Memorandum Circular no. 55 (MC 55) signed by the President which mandated government agencies to make use of biodiesel as fuel blend in its diesel engine vehicles. However, its adoption was low and biodiesel production through 2007 was expected to increase in view of RA 9367 [44].

Fig. 6 shows the trend of biofuel production in Philippines for both ethanol and biodiesel. There was no significant fuel ethanol production until 2009. Although the Biofuel Act had mandated that by January 2009 E5 would come into place, local production of ethanol had been problematic making timely compliance with the mandated blend possible only through imported ethanol [39]. Until 2009, there were only 2 ethanol production facilities in commercial operation and domestic ethanol production was less than the annual capacity due to delayed plant operations [39]. Local ethanol production continued to have difficulties and the production in 2010 was also low. This was due to inadequate investments, increasing sugar prices as well as stiff competition from imported ethanol from Brazil and Thailand, which also led to delay in implementation of E10 mandate from early 2011 to August 2011[46]. However, production of ethanol in 2011 increased after sugar prices stabilized and infrastructure improvements were instituted by oil companies [46]. Ethanol production 2012 onwards is likely to further increase with the expected operations of 2 new distilleries with a combined 92 million l capacity [46].

The biodiesel production has been fairly satisfactory in the Philippines over the years especially after the enactment of the Biofuel Act. The mandated blend of 1% by 2007 (3 months from the affectivity of the act) and 2% by 2009 was easily met due to adequate CME production capacity. In 2010, although there were 12 biodiesel plants with combined annual capacity of around 400 million l, only 8 were in commercial production [46]. Biodiesel production has remained fairly flat since 2009, mainly due to local coconut industry's capability to provide the adequate biodiesel feedstock [46].

Table 4 shows the number of ethanol and biodiesel plants in the Philippines. Although the numbers of plants established have been fairly constant over the years, production capacities have slightly improved.

3. Drivers of biofuel development

This section discusses the underlying driver for biofuel development in the selected ASEAN countries. The major drivers for the deployment of biofuels policies in these four countries include, among others, concerns on security of energy supply, socio-economic concerns such as income generation for farmers, and environmental concerns particularly to address climate change [1,3,9,10,47,48].

3.1. Energy security concern

Energy security refers to the supply of energy that is adequate, affordable and reliable and the primary reason for most Asian countries to promote biofuel production is to address its energy security concern [10]. According to Brown and Huntington [49], energy security can be improved by reducing the vulnerability of economic activity in a country to potential disruptions of energy supply and by replacing it with less vulnerable supply. All the ASEAN countries discussed here import oil. Indonesia, for example, switched from being a net exporter of oil to a net importer in mid 2000s. Therefore, the countries are finding ways to supplement, replace and diversify conventional energy sources to alternative and non-exhaustive sources of energy. Biofuels are thus seen as a credible option as they blend easily with fossil fuels thereby reducing the quantity of fossil fuel imports and the development of renewable energy, including biofuel production, is believed to be one of the paths to achieving energy security [10]. The underlying set of factors that thrust the countries to be energy secure includes the increase in global oil price to reduce their dependence on oil import, and to diversify their energy sources from fossil base.

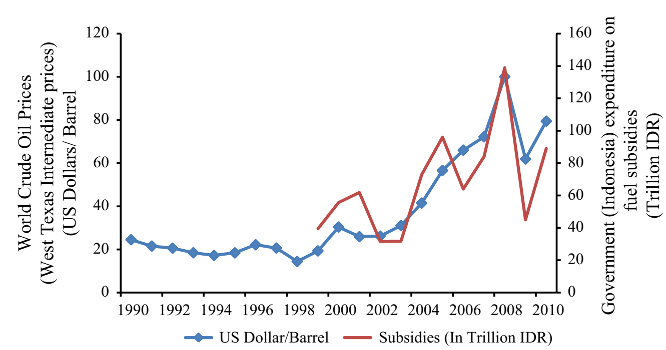

Fig. 7. Comparison of Indonesian government expenditure on fuel subsidies against world crude oil prices. (Data for World CPO prices obtained from BP Statistical Review [52]. Data for Indonesian government expenditure on fuel subsidies for 1999–2004 obtained from Dillion et al.,[22] and data for 2005–2011 obtained from Budget statistics [53].) Note: Average Indonesian Rupiah exchange rate: IDR.9250 = 1 US$ in 2011.

Table 4
Number of biofuel plants approved/registered in Philippines (2006–2011) [45].

Year	No. of approved/registered fuel ethanol plants			No. of approved/registered biodiesel plants		
	No. of ethanol plants	Combined production capacity (million l)	Capacity in use (%)	No. of biodiesel plants	Combined production capacity (million l)	Capacity in use (%)
2006				10	150	1
2007				12	325	12
2008				12	325	20
2009	2	40	63	12	395	33
2010	3	79	13	12	395	35
2011	3	79	37	12	395	36

3.1.1. Increase in global oil price

The global price of crude oil has increased over the years (see Fig. 7). The supply disruptions and uncertainties have also led to sharp fluctuation in the price of oil and the domestic oil prices in the importing countries have also increased in line with the global price. A 25% increase in oil prices causes the typical oil importer (where net oil imports have averaged between 3% and 4% of GDP) to experience a cumulative output loss of around 0.3% of GDP over a 2–3 year period, and for countries with oil imports greater than 5% of GDP, the output loss increases to about 1% [50]. Fig. 7 also shows an example of increased government expenditure in fuel subsidies in Indonesia. The increase in subsidies follows the trend in increase in global oil price fluctuation. In 2012, the Indonesian government's expenditure on energy subsidies was more than its combined investments in defense, education, health and social security, with estimates of the subsidy in 2013 to be 24% of government's total planned expenditure [51]. This causes strain on government budget and resources. All the countries of the ASEAN discussed here are net oil importers. Investing on renewable energy options like biofuels can thus help the countries to be less dependent on oil imports and be less influenced by the increasing oil price.

3.1.2. Reduce dependence of oil import

Against the backdrop of increased global oil prices, one of the options to reduce the dependence of oil import is to increase the domestic oil and gas production. An important criterion to measure the vulnerability of energy security is to measure the oil import dependency i.e. the percentage of oil used in the countries that must be imported.

Fig. 8 shows the energy security of these ASEAN countries measured in terms of oil import dependency for crude oil and petroleum products. It presents the net flow of foreign oil as a percentage of oil consumption and higher value depicts higher dependence to import oil. Energy importing countries like Thailand and Philippines are largely dependent on foreign oil imports. For e.g. Thailand was dependent on energy imports (for crude oil and petroleum products) for more than 40% of its primary energy supply until 2004. However, the dependency has decreased after 2004 onwards which could be attributed to its rigorous renewable energy policies such as Alternative Energy Development Plans which promoted greater share of renewable energy resources, including biofuel, to the national energy mix. Similar trend is observed in Philippines, where the dependence to foreign oil import has decreased in the last decade, due to the substitutions of conventional fuels by renewable fuels. However, in the case of energy exporting countries like Indonesia and Malaysia, the trend has been reversed. In the past decade, these countries have become less self dependent on oil and their export have decreased over the period. Particularly, the status of Indonesia, which switched to net energy importer during mid 2000s, depicts that Indonesia's reserves continue to diminish and it becomes even more important for it to look for other sources of oil for energy security.

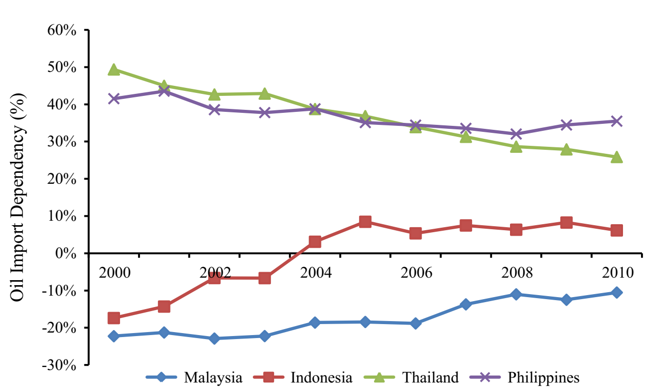

Fig. 8. Energy security under oil (crude oil and petroleum products) import dependency (Data obtained from APEC Energy Database [54].).

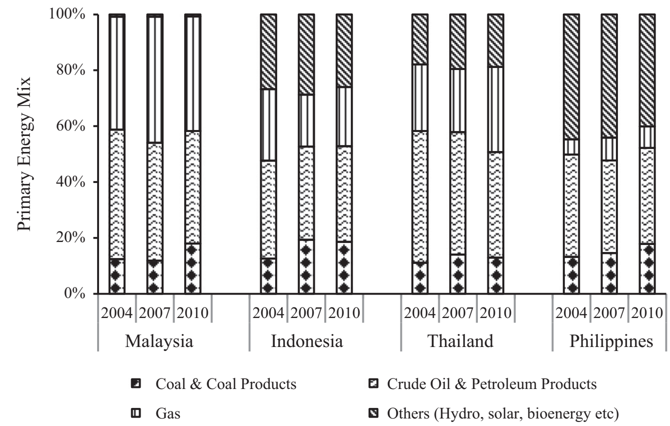

Fig. 9. Share of Primary Energy Supply Mix of ASEAN countries (Data obtained from APEC Energy Database [54].).

3.1.3. Diversify energy sources from fossil base

One of the ways for countries to respond to decreasing energy security due to fuel supply disruptions is to diversify their energy resources away from fossil base to more alternate and renewable options. By developing domestic resources and diversifying fuel types, countries can widen their diversity of supply and thus reduce the impact of oil price increases [55].

Fig. 9 compares the share of primary energy supply mix of these ASEAN countries in 2004, 2007 and 2010. The energy mix is heavily dominated by crude oil and petroleum products. The share of non-conventional energy resources such as hydropower, geothermal, wind energy and bio-energy (including biofuels) are minimal. The share of renewables in Indonesia and Philippines are due to geothermal energy as these countries are one of the largest producers of geothermal energy in the world. The share of renewable and alternate energy resources (based on bio-energy) has slowly gained momentum in the most import dependent country Thailand, and is likely to increase more in the future due to the prevalent support for renewable energy development. The heavy reliance on fossil fuels is a motivation for the countries to diversify their energy sources to a more renewable and stable supply.

3.2. Socioeconomic concern

Apart from improved energy security, there exist other societal and economic benefits that can result from increased biofuel production. The socioeconomic impacts can vary widely in terms of location, climate, market and policy environment. The underlying drivers for biofuel development under socio-economic category include increase opportunities of income generation for farms, access to new market, need to balance trade and foreign exchange, and resource potential.

3.2.1. Income generation and employment for farmers

Biofuel has the potential to provide employment in the rural areas and contribute to poverty alleviation and therefore the need to support agrarian economies is one of the significant policy drivers for the promotion of biofuels by the government [1]. Yan and Lin [10] discuss that the cultivation and harvest of feedstock

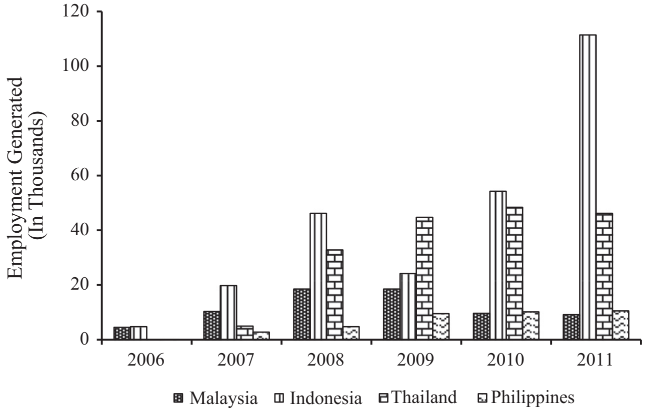

Fig. 10. Employment generation (in thousands) based on jobs created per year per million liters of biodiesel production (The production data for Malaysia, Indonesia, Thailand and Philippines were obtained from obtained from BP Statistical Review [7], Slette and Wiyono [26], Preechajarn and Prasertsri [32], and Corpuz [45] respectively.). Note: The jpMLy value as devised by APEC [58] for palm based biodiesel is 73.3 (applicable to Malaysia, Indonesia and Thailand that produce biodiesel from palm oil). In case of biodiesel production in Philippines which uses coconut oil, the jpMLy value is taken the same as that of palm oil (as proxy).

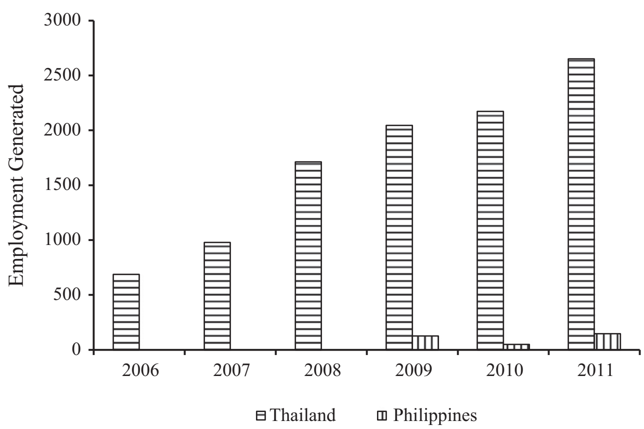

Fig. 11. Employment generation based on jobs created per year per million liters of ethanol production (The production data for Thailand and Philippines were obtained from Preechajarn and Prasertsri [32] and Corpuz [45] respectively.). Note: The jpMLy value as devised by APEC [58] for sugarcane based ethanol is 5.1 (applicable to Thailand and Philippines that produce ethanol from sugarcane).

crops require extensive labor and manual work thereby increasing employment in the agriculture sector. It also offers income-generating opportunities for farmers, as well as, promotes small holder participation in biofuel crop production. For example, palm oil industry contributed to about 5–6% of Malaysian GDP in 2007 and provides employment to around 1.4 million workers in the related industry [56]. A study on the impact of biofuels in the Greater Mekong Sub region (GMS)[2] reveal that the global biofuel development will significantly increase agricultural prices and production and change trade in agricultural commodities in GMS and the rest of the world. With rising agricultural prices and corresponding rise in land prices and agricultural wages, farmers' incomes will also improve [57]. Therefore, biofuel development shows significant potential to support the rural agricultural based economy.

Biofuel development increases employment and provides job opportunities to many. Figs. 10 and 11 show the employment generation based on jobs created per year per million liters (jpMLy) of biodiesel and ethanol production respectively. It is based on similar study by APEC [58], which uses an appropriate jpMLy value that varies with the type of feedstock used in the production, to each member country to arrive at approximate employment figures. A comparison of the employment numbers suggest that the approximate employment generated from the first-generation biofuel production in 2011 could be as high as 48,000 in Thailand (considering both ethanol and biodiesel production) and more than 100,000 in case of Indonesia from the production of biodiesel only. However, since these calculations are based on the estimates of production from particular feedstock, the employment figures are not equivalent to current biofuels employment. Instead, they represent rudimentary estimates of job potential from first-generation biofuels production.

3.2.2. *Access to new market*

Biofuel development also provides option of additional new market to local farmers and producers. Farmers get the opportunity to minimize the risk of decline in food crop demand by diverting crops toward biofuel production and with an additional market they can possibly get better prices for their crops [3]. Biofuel expansion could generate additional income and open markets, encouraging expansion of biofuel supply and development [8]. Since the production of biomass is cheaper in the ASEAN region (due to favorable climate and cheap labor costs), than that of developed nations, the trade of biofuel/biomass is also likely to increase from developing to developed countries. A study by UNCDT [59] reveals that if developed countries in EU and the US expand their biofuel sectors to fight global warming, the value of imports from developing countries could reach over $520 billion by 2020. Therefore, the potential of biofuel to expand to both local and international markets can encourage the developing countries into its production.

3.2.3. *Maintain trade balance and foreign exchange*

The need to protect trade balance and foreign exchange is one of the reasons for governments to develop biofuel policies [3]. Due to dependence in foreign petroleum imports, many Asian countries have had negative trade balances and outflow of foreign exchange and the savings in foreign exchange is an important reason for domestic biofuel production when the oil prices are high, [3,60]. For example, in Brazil the replacement of gasoline by bioethanol saved some US$ 43.5 billion between 1976 and 2000 (US$ 1.8 billion/year) [60,61]. Table 5 shows the value of total oil imports in the four ASEAN countries. The high and increasing value of imports provides a positive implication for biofuel development.

3.2.4. *Resource potential*

Tropical regions like ASEAN are naturally blessed with arable land for biomass production. The high level of agricultural output in this region has also led to surpluses of agricultural products which could be diversified for biofuel production. Doku and Falco [5] have assessed the comparative advantage of a naturally endowed arable

Table 5
Value of total oil imports in Billion US Dollars [62].

Country	1990	1995	2000	2005	2010	2012
Malaysia	1.293	1.442	3.474	8.360	12.383	17.974
Indonesia	3.400	3.900	5.756	16.018	24.344	43.043
Thailand	3.066	4.771	7.559	20.827	31.884	50.076
Philippines	1.842	2.461	3.877	6.280	9.589	16.139

The value for 2012 is estimate.

[2] The Greater Mekong Subregion (GMS) is a natural economic area bound together by the Mekong River including countries such as Cambodia, People's Republic of China (PRC, specifically Yunnan Province and Guangxi Zhuang Autonomous Regions), Lao PDR, Myanmar, Thailand and Vietnam.

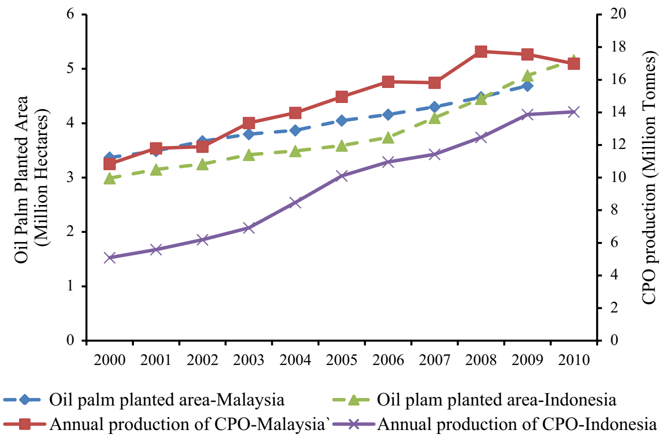

Fig. 12. Oil palm planted area and production in Malaysia and Indonesia (Data for Malaysia and Indonesia obtained from MPOB [63] and Statistics Indonesia [64] respectively.).

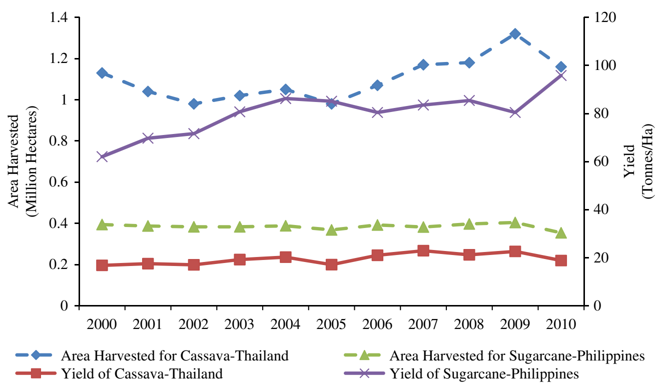

Fig. 13. Harvested Area and Yield for Cassava in Thailand and Sugarcane in Philippines (Data obtained from FAOSTAT [65].).

land and feedstock prices as one of the drivers for biofuel policy development. According to their research, the ability to financially support biofuel sector (e.g. the role of GDP) is an important factor to Organization for Economic Co-operation and Development (OECD) countries, whereas the availability of arable land and agreeable climate is important to developing countries. For example, the availability of palm oil, key feedstock for biodiesel, has been relatively abundant in Malaysia and Indonesia. Between 2000 and 2010, although the planted area of Crude Palm Oil (CPO) has less than doubled, the productions of CPO in Indonesia has increased almost 3 times (see Fig. 12). Similarly, Fig. 13 shows the harvested area and yield of two major feedstocks for ethanol production—cassava and sugarcane in Thailand and the Philippines, respectively. Although there is variation in the area harvested over the years, the yield has been relatively more or less stable for the same area.

Apart from the relative abundance of feedstock, these countries also have the benefit of lower per unit production cost of the biofuel. They also have relative advantage over developed countries in terms of biofuel production cost. The ethanol production in developed region/countries like EU (from wheat or sugar beet), US (from maize) costs around 70–81.6 and 36.8–50 US dollars per barrel respectively, whereas the ethanol production in Thailand (from sugarcane) costs around 43.2 US dollars per barrel [66]. Similarly, biodiesel production in EU (from rapeseed) and US (from soybean) costs around 64–128 US dollars per barrel whereas the same for Malaysia and Indonesia from oil palm costs around 62.4 and 73.6 US dollars per barrel respectively [66]. Usually for biodiesel, feedstock cost represents 80–90% of total production cost for vegetable oils, and for ethanol feedstock cost represents 50–80% of the total production cost [6]. The relatively lower cost of production in these countries is mainly due to lower cost of feedstock production. Thus, the high resource potential particularly the availability of ample arable land and cheap feedstock prices in these regions make promotion of biofuels a viable option.

3.3. *Environmental concern*

Although the environmental benefits of biofuels depends on how they are produced and managed, the main environmental concern for biofuel production is the reduction in GHG emissions.

3.3.1. *GHG emission reduction*

Under the climate change debate, attention is on reducing the carbon emissions with low carbon options of alternative/renewable energies. Generally, biofuels are considered carbon neutral as the carbon released from burning it is removed from the atmosphere by growing the plant [67]. In case of ethanol, the greenhouse gas reduction with respect to conventional gasoline, on well to wheel basis, is about 13%, up to 90% for sugarcane based ethanol, and 40% to 60% reductions in case of oil seed derived biodiesel [68]. A study on the potential of biomass and bioenergy in Southeast Asia between 1990 and 2005 showed that the carbon emission reduction associated with using woody biomass instead of fossil fuels for energy was between 202 and 336.7 Tg carbon per year [69]. Similarly, the life cycle GHG emission from Malaysian oil palm bioenergy indicates that using various combination of land types, Malaysia could meet the 5% biodiesel blending target in its transport fuel with a net GHG reduction of about 1.03 million t (4.9% of the transportation sector's diesel emissions) when accounting for the emissions reductions from the diesel fuel displaced is considered [70].

The emissions generated from indirect land use change due to biofuel production can also counteract the greenhouse emissions reduced from biofuel use. The life cycle emission of greenhouse gases associated with plant oils used as biofuel have higher emissions than conventional diesel when one considers not only fossil fuel inputs but also N_2O emissions and change in carbon stocks of agro ecosystems linked to cultivation of biofuel crops [71]. On the other hand, if landuse change associated with biofuel production is managed and biofuel is production is based on improved productivity or yield of the crops rather than conversion of land, reliance on biofuels as alternative energy source is seen as a positive step towards reduction of GHG and addressing the climate change issues. However, all the ASEAN countries discussed here are non-Annex 1 countries not requiring capping their emissions under the current Kyoto Protocol. Addressing climate change is not considered as a main driver for biofuel development in most of Asian countries [10], also noted in Section 2.

3.3.2. *Local pollution*

Apart from reducing the GHG emissions, biofuels have the potential to curb local air pollution by reducing the emissions of key pollutants usually emitted by other fuels. A life cycle inventory of CO_2 and NO_x emissions by burning 10% molasses-based ethanol (E10) in Thailand showed that there is a 4.3% and 3.1% reduction respectively compared with gasoline burning [72]. A study by Dufey [60] suggested that the engines running on biofuels or on a blend of standard fuels and biofuels tends to have lower particulate, CO and sulfate emissions. Due to their higher oxygen content, the hydrocarbon in the ethanol blended gasoline burns completely thereby reducing air pollutants like CO and hydrocarbon. One of the drivers of ethanol industry in US during 1990s was to reduce the CO and hydrocarbon when their emission was higher (mainly in winter) [73]. Transport related emissions are one of the major contributors of air

pollution in urban areas. Since most of the ASEAN countries have rapidly urbanizing cities and mega-cities, the reduction of air pollution due to biofuel usage can be an incentive for governments to opt for biofuel development.

4. Commonalities and differences in biofuel development

This section discusses the biofuel development in these ASEAN countries, considering their policies and drivers.

The review of policies, and production and utilization of biofuels in the above mentioned countries (as noted in Section 2) reveal some interesting trends. While Thailand and Philippines appear to have shown steady growth in building up both ethanol and biodiesel production, Malaysia and Indonesia suffered a ‘boom and bust’ cycle. The trend also generates questions like if the growth can continue and whether the bust be reversed. Although policies (including blending mandates) contribute significantly to this boom and bust, other factors like feedstock prices, tax structure, export tariff, nature of contract with producers, domestic consumption, and production efficiency etc., also play a role and the magnitude of these factors vary for each of the countries.

In general, in spite of occasional setbacks, Thailand and Philippines seemed to have achieved steady growth in production and development for both ethanol and biodiesel. For example, in Philippines biofuel usage are regulated by legislation and the blending mandates were implemented effectively without much prolonged wait. Coupled with increasing demand and timely enforcement of blending requirements, the biofuel growth has been sound over the years. Similarly in Thailand, although the actual production in 2011 was not able to meet the targeted production (as noted in 15 year AEDP), nevertheless the growth for both ethanol and bio-diesel was on a positive track [32,74]. Preferential tax system (which subsidizes the biofuel prices from the contribution of state oil fund from conventional fuels) that make retail price of biofuel less than that of conventional fuel, is one of the factors that lead to increased consumption and production of biofuels. Combined with mandatory blending requirement (e.g. for biodiesel) and revision of targets (10 year AEDP) it is likely that the growth will be positive in coming years.

On the other hand, there has been stagnant growth for ethanol in case of Malaysia and Indonesia. Ethanol production has been insignificant in Malaysia as sugar rich substrate (like sugarcane) is expensive and the ethanol production from starchy crops (e.g. sago, sweet sorghum) although promising, is yet to be fully commercialized [75,76]. Ethanol production in Indonesia have also seen major setbacks since 2010. The disagreement between local bioethanol producers with the Ministry of Energy and Mineral Resources (MEMR) for setting local market price index has ceased the ethanol production for the transportation sector [28].

Other noteworthy case is the biodiesel production in Malaysia, which unlike in Indonesia (as both are leading palm oil producers and exporters of the region) has dwindled significantly in the last few years. According to Pratica [77], compared to Indonesia there are several issues in Malaysia that has hampered its biodiesel sector. For instance, Malaysia lacks suitable land for oil palm plantation as there is government policy which requires 50% of land to remain forested. Also, the yield of oil palm is low in Malaysia compared to Indonesia where majority of oil palm trees are in pre-peak harvest growth stage. Malaysia also has differential export duty for CPO and biodiesel compared to that of Indonesia. Indonesia's duty which is 2% for biodiesel compared to 16.5% for CPO against Malaysia that has equal export duty of 30% for both biodiesel and CPO favours Indonesia's biodiesel exports and subsequently encourages its production [18]. By qualifying the International Sustainability and Carbon Certification (ISCC), the producers in Indonesia have been able to arrange long-term

Table 6
Summary of the ASEAN biofuel policies and the underlying drivers.

Country	Major feedstock	Policy aspect			Policy drivers and their importance								
					Energy Security concern			Socio-economic concern				Environmental concern	
		Policy target	Blending mandate	Economic measures	Reduce oil import dependency	Diversify energy sources	Global oil price increase	Income generation/ employment	Access to new market	Resource potential	Maintain trade balance	GHG emission reduction	Local pollution
Malaysia	Diesel: Palm oil	No specific policy targets	Diesel: B5	Tax incentive to manufacturers, no export duties, low interest loans, federal grants for R&D and demonstration projects	**	***	***	**	***	***	***	**	*
Indonesia	Diesel: Palm oil	Target biofuel mix of 2%, 3% and 5% in total energy mix by 2010, 2015 and 2025 respectively	Diesel: B5 Ethanol: E3	Diesel subsidized to same price as fossil fuel	***	***	**	***	**	***	**	*	*
Thailand	Diesel: Palm oil Ethanol: Cassava	Targeted biofuel share to be 4.1% in the 20% alternative energy mix of country's total demand in 2022	Diesel: B5 Ethanol: E10	Diesel: soft loans, subsidies to lower the price of B5 than B2 blends Ethanol: tax exemption for producers; subsidies to refineries; reduction on import duties for compatible automobile manufacturers	***	***	***	**	**	***	**	*	*
Philippines	Diesel: Coconut oil Ethanol: Sugarcane	No specific policy targets	Diesel: B2 Ethanol: E10	Tax exemptions, financing schemes to encourage domestic production	***	***	**	***	**	**	***	**	*

Ratings: Author's judgment.

business contract with European biodiesel blenders which have been a strong incentive in Indonesia to export and produce biodiesel [26].

The selected ASEAN countries also have primary reasons that have driven the development of biofuel policies. The main driving forces for the development of biofuel in the ASEAN countries are their concern for energy security particularly to diversify their energy sources to reduce their dependency on oil import and socio-economic concern such as increased opportunity of income generation/ employment for farmers. These ASEAN countries, like elsewhere in the world, due to the dramatic oil price increase of 2007–2008 rushed to promote biofuels [78,79], and thus developed biofuel policies with primary aim of ensuring energy security. On the other hand, addressing climate change (like OECD countries) does not seem to be the main driver in these countries as they are non-Annex countries that are not required by the Kyoto protocol to cap their emissions [3].

Table 6 summarizes the key aspect of biofuel policies in the ASEAN region. The importance of the drivers has been indicated with '*' sign with importance increasing with greater number of '*' signs. The ratings have been done based on the objectives, guiding principles, expected outputs and related information of the biofuel policies of these countries as noted in Section 2.These drivers may not be the only and existing focus of the biofuel development in these countries, nevertheless, it gives an idea on the relative importance of factors underlying biofuel development and policies. Although each country has blending mandate and economic measures to promote the biofuel development, only Thailand and Indonesia have specific policy targets. Also, the main driving forces for the development of biofuel in these countries are their concern for energy security and socio-economic concern whereas environmental concern is not much of a priority.

5. Impacts and way forward

Through the pronouncement of biofuel policies and economic measures like subsidies, mandates, tax leverage, the four countries have demonstrated their support for the expansion of (first generation) biofuel industry. But, it is important to consider that although the economic measures could support rapid expansion of the biofuel industry, it could also exacerbate pressure on the prevailing resources. Subsidy payment and tax exemptions could become more costly as production rises, and thus the countries need to evaluate their policies in light of emerging evidence on the impacts of biofuels production and utilization [80].

Although biofuel development possess a number of socio-economic, environmental and technical benefits over fossil fuels, their impact particularly on landuse, food prices and overall welfare of the farmers is still debated and cannot be overlooked. Biofuel development creates incentive to convert forests into biofuel crops thereby affecting landuse and biodiversity. For example, it has been estimated that slightly more than half, around 7 million hectares of oil palm expansion in Malaysia and Indonesia, have occurred at the expense of forests and the drive for large-scale agro-industrial projects will continue to threaten forest and biodiversity in both countries [81]. Similarly, the land-use change induced by the expansion of croplands for biofuel production can, in fact, release more carbon than the carbon savings gained by using biofuels. For example, a study on the GHG performance of bio-ethanol in Thailand showed that cassava plantation which included direct landuse change by expanding grass land to cultivated land yielded more GHG emissions (almost 3 times more) than the case where plantation involved improving yield and productivity [82]. The most debated aspect of biofuel is probably on the extent to which biofuel impact the food prices and food security. For example, in May 2007 when China implemented a policy to prevent biofuels production on land traditionally devoted to staple grains, it started to look for feedstock outside its borders, which may have contributed to the export price of cassava from Thailand. Consequently, in Thailand in 2007, the export price of tapioca (a cassava product important for its overall cost) rose by 45%, with a similar rise in domestic wholesale price [81]. This implies that when the exported agricultural commodity fetches higher price than those in the domestic market, the governments may not always be able to protect their citizens from impact of high food prices, [81] which affects poor and vulnerable, the most. A economic analysis conducted by Yang et al. [57] for assessing the impact of biofuel in GMS reveals that the global biofuel development will significantly increase agricultural prices production and change trade in agricultural commodities in the GMS as well.

In light of impacts described above, these ASEAN countries will have to carefully plan their intention for biofuel development so that it does not compete with other social and environmental needs. Therefore, it becomes important to understand the underlying drivers of biofuel policy because the policies vary depending on the prevailing drivers. According to Wiesenthal et al., [2], if the prevailing driver for biofuel policy is the reduction of greenhouse gas emission, a policy supporting an accelerated introduction of advanced biofuels may be beneficial as the these technologies usually have lower per unit GHG emissions than conventional ones. On the other hand, a biofuel policy that primarily aims at enhancing energy supply security would try to limit the share of imported biofuels, and if it aims at creating alternative outlets for agricultural products, limiting import levels would be one consequence.

These ASEAN countries need to ensure that the energy security concern does not jeopardize the income and welfare of the poor. Although the biofuel expansion may generate additional income within the agriculture sector and open export markets for developing nations, the undernourished and vulnerable populations might remain unable to purchase food at these prices despite production capacity and food availability [10]. Production of second generation biofuels using agricultural residues and energy crops provide incentives to reduce the environmental impacts as well as ensure welfare benefits to the poor.

Opportunities under carbon finance of Kyoto Protocol, such as Clean Development Mechanism (CDM) could play a role to further raise the biofuels production and utilization in these countries. Although Asia and Pacific host more than 80% of all the Clean Development Mechanism (CDM) projects [83], within Asia these ASEAN countries are not a significant host for CDM projects compared to the global leading CDM host countries like China and India [83,84]. The situation is even bleaker for biofuel (compared to other renewable) under CDM projects mainly due to sustainability issues of biofuel such as deforestation, food-fuel conflict, loss of biodiversity, water scarcity, etc; lack of baseline data and methodological complexities [85]. Global CDM pipeline (until April 2013) indicate that there was only one biofuel project (biodiesel) registered in CDM (and 7 projects at validation stage) and no Certified Emission Reduction (CER) credit from biofuel has been issued yet [83]. Since biofuels have the potential to contribute to GHG emission reduction, there exists opportunities for biofuels through greenhouse gas emissions reductions using national and international protocols (e.g. CDM under Kyoto Protocol). The growth potential of biofuel can be translated into economic review through GHG emission reduction and address climate change.

The approved methodologies under CDM for biofuel projects applies to biofuel produced from waste oil/fats or vegetable oil; produced using mixed feedstock; and produced from dedicated plantations in degraded or degrading lands prior to the cultivation of oil plants [85,86]. Since the energy portfolio of ASEAN countries are largely based on biomass, large CDM potential remains to be

explored. Utilization of second generation biofuels derived from agricultural residues has shown the potential to displace about 25–69% of ethanol consumption in transportation fuel in Thailand [74]. Other research have also shown the potential of biodiesel production from non-edible plants like Jatropha in Malaysia, Indonesia, Thailand [87–89] to reduce GHG emissions and provide other socio-economic benefits. Although there is no mandatory provision of biofuel production utilizing second generation technology (from agricultural residues, lignocellulosic biomass) at policy level in these countries, nevertheless some of the countries have shown interest in second-generation biofuels as way forward. For example, the AEDP (2012–2021) of Thailand [31] has identified research and development of the 'future new fuel of diesel substitution' with a target of commercial production of 25 million l/day by 2021. The scheme focuses on research for new fuel development by using new energy crop (e.g. jatropha, micro algae), developing innovative ways of blending; developing pilot project and conducting trial fleet test to decide most optimal fuel; and finally starting commercial production of the second generation biofuel. Similarly, production of second and third generation biofuels has been identified as one of the prioritized options for possible renewable energy mitigation technology under the national Technology Needs Assessment for climate change mitigation in Thailand [90]. Therefore, the value of sustainably produced biofuel in the carbon market could drive the ASEAN countries to produce second generation biofuels (through non-edible feedstocks) in the future.

Moreover, assuming further liberalization of ASEAN market after the realization of ASEAN Economic Community (AEC)[3] in 2015, which will remove barriers to trade and stimulate competition, the change in the market structure of biofuels in the region is quite likely. According to Kojima et al. [92], liberalizing biofuel trade is likely to increase demand for biofuels by reducing prices in previously protected markets. The immediate effect of trade liberalization would be an increase in feedstock prices, fall in byproduct prices on the world market, and a fall in prices for heavily protected domestic producers. The impact could be different to each country, with likelihood of small economies currently having high tariff becoming worse off. Therefore, biofuel development in these countries must take into account the full spectrum of market and societal values, such as forgone food and agricultural output, impacts on environmental services and overall improvement in the well being of the rural poor [57].

6. Conclusions

This paper reviewed and analyzed the biofuel policies of the major biofuel production nations of the ASEAN—Indonesia, Malaysia, Philippines, and Thailand. The potential of biofuel as an alternative source of energy in these ASEAN nations indicates that biofuel will form an important part of energy supply in these countries. A large variety of biofuel support policies are in place ranging from tax exemptions, mandatory blending targets, subsidies and other financial schemes to stimulate the development and adoption of biofuels in the region. Indonesia and Thailand have specific policy targets related to biofuel development with targeted biofuel share in country's total energy mix. Malaysia and Philippines, although have National Biofuel Policy and biofuel law respectively, lack specific policy targets with regards to biofuel development. Thailand and Philippines show upward trend in the production of both ethanol and biodiesel, whereas Malaysia and Indonesia have promising trend only for biodiesel as ethanol production have been either insignificant (Malaysia) or nearly ceased during the last few years (Indonesia). Indonesia is leading the region in biodiesel production (total production of around 1500 million l in 2011) and Thailand is leading in ethanol production (total production of around 500 million l in 2011). Although each of these countries have had occasional setbacks in their production in the past and their future production will depend on many other factors (e.g. feedstock prices, production efficiency, etc), in totality, an upward trend in biofuel production in the region is likely with increased demand, consumption, enforcement of mandates and simply with realization of policy targets.

The policy target of these ASEAN countries to increase the share of biofuel in their energy mix is motivated by several factors, mainly their energy concern to reduce the dependence on oil import and socio-economic concern, such as to increase the employment and income generating opportunities in the rural areas. Climate change is currently not the primary motive of these countries to pursue biofuel development policies as most of these nations are developing countries not yet binded by international commitments to curb their carbon emissions.

The current measures for biofuel development are more reliant on first generation biofuels to meet the alternative energy needs. Although the countries discussed here are looking at the opportunities for second generation biofuels through the promotion of alternative feedstock like jatropha, cassava, and have initiated some pilot projects; sufficient research, technology and investment in second generation biofuels are still lacking to produce modern and less damaging biofuels. Development of second generation biofuels will not only help in addressing the energy concern and ensuring that there is no competition with food crops for production of biofuel; it will also provide opportunity for the countries to gain from carbon finance (such as CDM) and subsequently address climate change issues. More research, specific policy interventions and dedicated support need to be put in place for sustainable production and utilization of second generation biofuels in these countries.

It will be a challenge for the governments to continue the expansion and development of biofuel sectors and also abide by sustainable production requirement. The key question is the long term economic, social and environmental sustainability of the biofuel development. The biofuel development must consider the market and societal issues, especially the welfare benefits to the poor and its impacts on environmental services.

[3] The ASEAN Summit in 1997 decided to transform ASEAN into a stable, prosperous, and highly competitive region with equitable economic development, and reduced poverty and socio-economic disparities, also known as ASEAN Vision 2020. Following the Bali Summit in 2003 it was declared that the ASEAN Economic Community (AEC) shall be the goal of regional economic integration by 2020. The AEC will establish ASEAN as a single market and production base with free flow of goods; services; investment; capital and skilled labor with priority integration sectors, such as food, agriculture and forestry [91].

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